(12) **EUROPEAN PATENT SPECIFICATION**

(54) **Method and device for power control in the base-to-mobile link of a mobile radio system with code division multiple access**

Verfahren und Einrichtung zur Leistungssteuerung in der Verbindung von der Basis zur mobilen Stelle im Mobilfunk mit Vielfachzugriff durch Codetrennung

Procédé et dispositif de contrôle de puissance en lien de la station de base à la station mobile d'un système de radiotéléphonie mobile avec accès multiple par répartition de code

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(56) References cited:
WO-A-92/21196   **WO-A-93/05585**
WO-A-93/21699

EP 0 656 716 B1

Description

[0001]   The present invention relates to mobile communications systems and in particular to a method and a device for power control in the base-to-mobile link of a mobile radio system using direct sequence-code division multiple access (DS-CDMA).

[0002]   It is known that according to this technique the binary information sequences individually generated by the users are multiplied by a respective very long pseudo-random sequence whose elements have a period (chip time) much smaller than the bit time of the information sequences, so that the energy of the signals from each user is uniformly spread over the whole system band. The pseudo-random sequence is typical of the user and represents a code for the same. The spread spectrum signals thus obtained are added together and sent to all users. At the receiving side, the information is recovered through decorrelation operations, by taking advantage of the code sequence. This technique helps keeping communication secrecy.

[0003]   An essential requisite of a system using this technique is power control, which is particularly critical in the mobile-to-base link, and yet is also necessary in the base-to-mobile link in order not to affect the system capacity in comparison with the other link, for a given transmission quality.

[0004]   In fact, in the mobile-to-base link it is essential that the signals sent towards the base station from different mobile stations locked thereto arrive at the base station ideally with the same power, because in the absence of power control the signals from a mobile station near the base station could completely mask the signals from a farther out mobile station. To face this problem (commonly called "near-far problem" in the art) high dynamics is required for power control, even in excess of 80 dB. In the base-to-mobile link, power control is less critical, as each mobile station receives from its base station a signal which is the sum of the useful signal (the signal actually intended for the mobile station itself) and of interfering signals (those intended for all other mobile stations): both the useful signal and the interfering signals follow the same path within the cell, and there is no such problem as explained above. However, the interference due to signals from the base stations of adjacent cells must be taken into account, and it was seen that only by applying power control in the base-to-mobile link too a carrier/interference ratio (i. e. the ratio between the power of the useful signal and the sum of the powers of the interfering signals) of the same order as in the reverse link can be obtained: in this way, capacity is essentially the same in both links, for a given quality.

[0005]   As regards power control in the mobile-to-base link, according to the most common technique each mobile station corrects the power level sent according to an estimate of the attenuation undergone in the base-to-mobile link by a pilot signal of known power level transmitted by the base station. Since the mobile-to-base link operates in a frequency band different from the one of the base-to-mobile link, the attenuation estimated as above is not the same affecting the signal in the mobile-to-base link. Therefore, the power level of each mobile station is then corrected upon command from the base station according to the power level received at the latter. This technique is described for instance in the paper "On the Capacity of a Cellular CDMA System", by K.S. Gilhousen et al., IEEE Transactions on Vehicular Technology, Vol. 40, No. 2, May 1991, pages 303-311.

[0006]   The possibility of carrying out a power control in the base-to-mobile link based on the distance of each mobile station from the base station is described in the paper "Power Control in CDMA" submitted by W.C.Y Lee to the VTS Conference, St. Louis, U.S.A., May 19-22, 1991, published on pages 77 - 80 of the Conference Proceedings. As a result of such control, the overall power transmitted by the base station is reduced, in that the base station transmits at a higher power level to mobile stations at the boundaries of the cell and at a lower power level to mobile stations near the base station. Practical application of this type of control is extremely difficult, as it causes continuous variation of the total power transmitted by the base station in a cell, which in turn prevents control of interference in adjacent cells.

[0007]   Moreover, even if such a control could be implemented, it has been recognized in the literature that its performance would not be satisfactory (see the paper "Power Control in Cellular DS CDMA Systems", submitted by R. Prasad, M. Jansen and A. Kegel to COST 231 TD(92)-92, Helsinki, Finland, September 8-11, 1992) and that better results can be obtained by performing power control in the base-to-mobile link on the basis of an estimate of the carrier/interference (C/I) ratio of each mobile station. The paper states that in this way the C/I ratio of each user is "minimised" according to his demands, which probably means that the power of both the useful signal and the interfering signal is minimized. No indication is given of how to obtain such a result.

[0008]   The purpose of the present invention is precisely to provide a method and a device allowing a simple and performing implementation of a power control in the base-to-mobile link based on an estimate of the C/I ratio.

[0009]   According to the invention, there is provided a method in which each of the active mobile stations locked to a base station measures its own carrier/interference ratio and provides the base station with information, periodically updated, on such ratio, characterized in that total power P is shared among all traffic channels active for transmission towards the mobile stations by assigning to each of them, in a time interval in which the carrier/interference ratio values are kept valid, a fraction $P_i = \alpha_i \cdot P/N$ of such total power (where N is the number of active channels and α_i is a coefficient typical of the channel, hereinafter called power control factor) depending on the carrier/interference ratios of all the mobile stations, on the number of active channels in the interval, on whether or not there have been variations in the

active channels relative to the preceding interval and on the power assigned to the channel in the preceding interval, the sharing of the power among the various traffic channels being such as to maintain constant, for a given number of active mobile stations, the total power transmitted by the base station to said mobile stations, and to equalize the carrier/interference ratios of all the mobile stations.

[0010] The invention also provides a device for implementing the method, in which each active mobile station locked to the base station of a cell sends to the base station information, periodically updated, on the respective carrier/ interference ratio, characterized in that it includes means for receiving such information and means for sharing among the various traffic channels towards the mobile stations the total power P available for transmission from the base station to the active mobile stations, so as to keep constant such total power, for a constant number of active channels, and to equalize the carrier/interference ratios of all the mobile stations, and in that the power sharing means are arranged to assign to each channel, in a time interval in which the carrier/interference ratios remain valid, a fraction Pi $= \alpha_i \cdot P/N$ of said total power P, where N is the number of active channels and αi is a coefficient typical of the channel, called in the following power control factor, depending on the carrier/interference ratios of all the mobile stations, on the number of active channels, on whether or not there have been variations in the active channels with respect to the preceding interval and on the power sharing carried out in the preceding interval.

[0011] The invention also concerns a mobile communications system with code division multiple access, in which power control in the base-to-mobile link is carried out, in every cell, according to the method and with the device herein described.

[0012] The invention will be now better disclosed with reference to the enclosed drawings, in which:

- Figure 1 is a diagram of the section for transmission towards mobile stations in a base station of a mobile radio system with code division multiple access, in which the present invention is used;
- Figure 2 is a graph depicting the performance of a system using the invention; and
- Figure 3 is the block diagram of a device implementing the method of the invention.

[0013] In Figure 1, $T_1 \dots T_N$ are the traffic channels carrying binary signal sequences relative to communications directed to the active mobile stations $M_1 \dots M_N$, locked to base station SB. The sequences originate from respective sources, not shown. Both the nature of the communications (voice, data ...) and their origin (from a mobile station or from the fixed network) are not of interest for the present invention.

[0014] Signals sent along those channels can be coded in encoders $C_1 \dots C_N$ and are then respectively multiplied by pseudo-random sequences or codes $PN_1 \dots PN_N$ in multipliers $ML_1 \dots ML_N$, resulting in spread spectrum signals occupying the whole available spectrum. These signals are then sent to variable gain amplifiers, $A_1 \dots A_N$, which bring the signals of the respective channel up to a desired power level, meeting the criteria stated in the following. The signals outgoing by amplifiers A_i are then linearly added up in adder SM1 and sent to conventional transmission means represented by block TR (within which modulation, filtering..., take place).

[0015] According to the present invention, each of the N active traffic channels is assigned a power Pi $= \alpha_i$Po, where P is the total power allotted to the transmission of N channels, Po $= P/N$ is the power that would be assigned to each channel in the absence of power control and α_i is a proportionality coefficient (called in the following "power control factor") typical of the channel and determined so as to equalize the carrier/interference (C/I) ratios of all the active mobile stations and to keep the total power P constant. Coefficients α_i are determined and periodically updated by a power control device CP on the basis of value Γ_i of the inverse of the C/I ratio at the various active mobile stations M_i. Device CP consequently adjusts the gain of amplifiers A_i. Values Γ_i are periodically provided (typically, with a periodicity of the order of a few tens milliseconds or at most a hundred milliseconds) by the mobile stations to base station SB, e.g., through a signalling and control channel, analogously to what is done for the power measurements necessary for controlling power in the mobile-to-base link. Receiving devices are shown in the whole as block RC. All the base stations of the system are equipped with device CP.

[0016] In steady state operation (i.e., as long as there are no variations in the active channels), device CP operates for each traffic channel in every cycle (a cycle being a time interval in which the C/I ratios and hence values Γ_i are kept valid) on the basis of three parameters: two of these are specific for the channel, namely value Γ_i and the power control factor α_i calculated by CP in the preceding interval (indicated by α'_i); the third parameter depends on the overall state of the system and is related to the number of active channels N and to the values Γ_i and α'_i of all the active channels.

[0017] More particularly, value α_i is calculated by CP according to the following relation:

$$\alpha_i = H(1 + \Gamma_i)\alpha'_i \qquad (1)$$

where H denotes the quantity

$$H = N/(N + \sum_{i=1}^{N} \Gamma i \cdot \alpha'_i) \qquad (2)$$

[0018] It can be immediately seen that power P is constant provided that in every interval coefficients α_i meet condition

$$\sum_{i=1}^{N} \alpha_i = N.$$

[0019] If, in addition to the mobile stations already active, X further mobile stations M_{j1} ... M_{jX} become active in a cycle, mobile stations M_1... M_N transmit with the same power as in the preceding interval (therefore $\alpha_i = \alpha'_i$); power control factors $\alpha_{j1} = ... = \alpha_{jX} = 1$ are initially assigned to the newly active mobile stations M_{j1} ... M_{jX}, so as to meet the condition that the sum of all factors α equals the number of active mobile stations in the cell. Values of C/I ratios are then again equalized by applying relations (1) and (2).

[0020] In the opposite condition, in which X mobile stations M_{j1} ... M_{jX} release the communication, so that only N - X remain active, coefficients α_i (i ≠ j1 ... jX) of the latter are updated according to the relation:

$$\alpha_i = \alpha'_i + K = \alpha'_i + \frac{\Delta_{j1} + ... + \Delta_{jX}}{N - X} \qquad (3)$$

where Δ_h (h = j1 ... jX) denotes the quantity α'_h - 1. Therefore a same initial power variation occurs for all the mobile stations. It can easily be that relation (3) too allows the condition

$$\sum_{i=1}^{N-X} \alpha_j = N - X$$

to be met for all the mobile stations remaining active in the cell. In the next interval the C/I ratios are equalized again according to relations (1) and (2).

[0021] By equalizing the C/I ratios for all the mobile stations locked to a base station the performance of the worst traffic channel is improved. Since, as it is known, a system is designed taking into account the worst case, it is clear that the invention allows improvement of the overall performance. Furthermore, as the total power transmitted by each base station (for a given number of active channels) is constant notwithstanding its periodic redistribution among the channels, interference into adjacent cells cannot vary in uncontrolled manner.

[0022] In the case of addition or release of active mobile stations in the cell, updating of power control factors α_i in the above mentioned way has the advantage of minimising C/I ratio variations, with respect to an alternative solution such as assigning again unit factors α_i to all channels.

[0023] Tables 1 and 2 attached show the values of coefficients α_i and C/I ratios in the absence of power control (Tables 1A, 2A) and in three different conditions of application of the invention, namely: steady-state power control, with N constant (Table 1B, 2B), activation of a farther mobile station (Tables 1C, 1D), release of a mobile station (Tables 2C, 2D). C/I ratios in the absence of power control are obtained through computer simulation, by assigning to the mobile stations arbitrarily different distances from the base station and arbitrarily different shadowing conditions in the mobile-to-base link. For all the values shown in the tables only three decimal places are considered; the values of α_i are also rounded off, depending on the value of the digit in the fourth decimal place.

[0024] As it may be seen, for a given number N of active channels, by applying the invention, the channel with the worst C/I ratio in the absence of power control is improved by about 4 dB. If a further mobile station becomes active, obviously all the C/I ratios worsen somewhat, yet to an extremely reduced extent (about 0.1 dB), as it can be seen from Table ID. Even the maximum degradation in the cycle in which the power must be shared among the new active channels is very limited (about 0.4 dB, see Table 1 C).

[0025] Analogously, overall improvement and maximum improvement are very limited in the case of release of a mobile station (about 0.1 dB and about 0.2 dB, respectively). It then appears that thanks to the invention there are no sudden changes in the overall performance of the system when the number of active users varies.

[0026] For simplicity, the case was not considered in which in the same cycle one or more channels are released

and one or more channels become active. On the other hand, this situation is highly unlikely, given the short duration of the working cycles given above. At any rate, should such a situation occur, it could be dealt with by handling the activation and the release of channels in succeeding stages.

[0027] The advantages of the invention also appear from Figure 2, which shows the C/I ratio versus the number of users per cell when using the invention (solid line) or without using it (dotted line) for the worst one of the mobile stations in a multicell system with omnidirectional antennas (which, for the case of ten users, essentially corresponds to the example in Table 1). The graph was plotted taking into account a 10% probability that the expected C/I ratio for a given number of users be exceeded. It can be immediately seen that, by using the invention, the C/I ratio for the same number of users can be improved or, vice-versa, the number of users which can be served by a cell with the quality desired can be increased.

[0028] Figure 3 shows a possible implementation of the power control device CP, assuming that a maximum number Q of mobile stations (and hence of traffic channels) may be active at the same time in the cell. Even though Figure 3 shows values Γ, α, α' for all Q channels, it is clear that they will be present only for the active channels, indicated in the following with indices k1 ... kN ($N \leq Q$).

[0029] This given, device CP includes, for each of the Q channels: an input buffer memory or register B_1, B_2 ... B_Q, which temporarily stores the value Γ provided by the respective mobile station when active; a first arithmetic unit $U1_1$... $U1_Q$ calculating power control factor $\alpha_1...\alpha_Q$; a second register R_1... R_Q supplying, at each cycle, values $\alpha'_1...\alpha'_Q$ assumed by the power control factors in the previous cycle; and multipliers $MT_1...MT_Q$ computing the products $\alpha'_i \cdot \Gamma_i$. Registers B_1 ... B_Q are necessary in that values Γ may not arrive all at the same time at the base station, whereas for the correct application of the algorithm it is necessary that they be simultaneously available to the downstream units. Therefore, values Γ stored in registers B_{ki} (i=1 ... N) associated with active channels are read all at the same time, upon command of a signal CK generated by a time base (not shown) of the base station. The same signal CK also commands reading, from registers R_{ki}, of the power control factors α'_{ki} calculated in the preceding cycle.

[0030] Units U1 receive: from a control logic LC, an operation mode selection signal SE indicating whether the active channels are the same as in the preceding interval, whether new channels have been activated or whether some channel has been released; from registers R_{ki}, factors α'_{ki}; from a second computing unit U2, the parameter H given by relation (2) or the parameter K appearing in relation (3). When signal SE indicates that the active channels have remained unchanged, units U1 calculate factors α according to relation (1). When SE indicates that new channels have been activated, units U1 supply, as values α, the preceding value α' for the channels already active and value 1 for new channels. If some channels have been released, units U1 calculate values α for the remaining channels according to relation (3). Values α generated by units U1 are sent to amplifiers A_i (Figure 1) and to registers R for use in the next cycle.

[0031] Multipliers MT carry out the product of value Γ and factor α', read from registers B, R associated with the respective traffic channel, and provide unit U2 with products $\Gamma \cdot \alpha'$. Unit U2 also receives signal SE from LC and values α', from registers R, and calculates parameter H or K when SE indicates that the active channels have remained unchanged or respectively that channels have been released. The information on the number of active channels is given to U2 by LC.

[0032] In order to generate signal SE, LC has to receive in each cycle information on the state of each channel and to store it for a full cycle to be able to recognise newly activated channels or released channels. Basing on such information, LC can immediately calculate the number of active channels N. Information of this kind is usually available in the control devices of the base station, which pass it to LC as depicted by arrow N. Furthermore, the information that certain channels have been released must also be passed on to U2 for calculating K. This information can be given by LC together with the number N of active channels.

[0033] It is evident that the above description is given merely by way of a non limiting example, and that variants and modifications are possible without departing from the scope of the invention as defined in the claims.

TABLE 1

mobile	A: no control		B: control; N constant	
	α_i	C/I (dB)	α_i	C/I (dB)
1	1	-11,148	0,556	-13,839
2	1	-17,130	2,088	-13,839
3	1	-17,527	2,285	-13,839
4	1	-10,948	0,533	-13,839
5	1	- 9,545	0,397	-13.839
6	1	- 9,566	0,399	-13,839
7	1	-15,233	1,363	-13,839

TABLE 1   (continued)

A: no control			B: control; N constant	
mobile	α_i	C/l (dB)	α_i	C/l (dB)
8	1	- 9,565	0,399	-13,839
9	1	- 9,709	0,411	-13,839
10	1	-15,860	1,569	-13,839

C: N=11;updated α_i			D: N=11; new control	
mobile	α_i	C/l (dB)	α_i	C/l (dB)
1	0,556	-14,150	0,586	-13,915
2	2,088	-13,924	2,093	-13,915
3	2,285	-13,917	2,286	-13,915
4	0,533	-14,163	0,563	-13,915
5	0,397	-14,269	0,429	-13,915
6	0,399	-14,267	0,431	-13,915
7	1,363	-13,969	1,380	-13,915
8	0,399	-14,267	0,431	-13,915
9	0,411	-14,255	0,443	-13,915
10	1,569	-13,952	1,582	-13,915
11	1,000	-12,764	0,776	-13,915

TABLE 2

A: no control			B: control; N constant	
mobile	α_i	C/l (dB)	α_i	C/l (dB)
1	1	-11,198	0,610	-13,472
2	1	-9,549	0,431	-13,472
3	1	-12,375	0,786	-13,472
4	1	- 9,575	0,433	-13,472
5	1	-16,111	1,800	-13,472
6	1	-12,311	0,776	-13,472
7	1	-17,287	2,347	-13,472
8	1	-15,564	1,592	-13,472
9	1	-11,357	0,631	-13,472
10	1	-11,070	0,593	-13,472

C: N=9; updated α_i			D: N=9; new control	
mobile	α_i	C/l (dB)	α_i	C/l (dB)
1	0,585	-13,329	0,577	-13,389
2	0,406	-13,265	0,395	-13,389
3	0,762	-13,363	0,757	-13,389
4	0,408	-13,266	0,397	-13,389
5	1,775	-13,425	1,789	-13,389
7	2,322	-13,436	2,346	-13,389
8	1,568	-13,419	1,578	-13.389
9	0,606	-13,334	0,599	-13,389
10	0,569	-13,325	0,561	-13,389

Claims

1. Method for power control in the base-to-mobile link of a mobile radio system with code division multiple access, in which each of the active mobile stations (M_1 ... M_N) locked to a base station (SB) measures its own carrier/ interference ratio C/I and provides the base station (SB) with information, periodically updated, on such ratio, characterized in that total power P is shared among all traffic channels active for transmission towards the mobile stations by assigning to each of them, in a time interval in which C/I ratio values are kept valid, a fraction Pi = $\alpha_i \cdot$ P/N of such total power, where N is the number of active channels and α_i is a coefficient typical of the channel, hereinafter called power control factor, which fraction depends on the C/I ratios of all the mobile stations, on the number of active channels in the interval, on whether or not there have been variations in the active channels relative to the preceding interval and on the power assigned to the channel in the preceding interval, the sharing of the power among the various traffic channels being such as to maintain constant, for a given number of active mobile stations, the total power transmitted by the base station (SB) to said mobile stations (M_1 ... M_N), and to equalize the carrier/interference ratios C/I of all the mobile stations (M_1 ... M_N).

2. Method according to claim 1, characterized in that the information on the carrier/ interference ratio sent by the mobile stations (M_1 ... M_N) is the inverse (Γ_1 ... Γ_N) of such ratio.

3. Method according to claim 1 or 2, characterized in that, in each interval in which there are no variations in the active channels, the power control factor α_i (i = 1 ... N) for an active channel is computed according to the relation $\alpha_i = H (1 + \Gamma_i) \alpha'_i$, where α'_i is the value of the power control factor for that channel in the preceding interval, Γ_i has the meaning stated above and H is a parameter given by

$$H \; = \; N/(N + \sum_{i=1}^{N} \Gamma_i \cdot \alpha'_i).$$

4. Method according to any preceding claim, characterized in that, in a time interval in which new traffic channels are activated, each already active channel is assigned the same value α'_i of the power control factor as assigned in the preceding interval and new channels are assigned a unit power control factor.

5. Method according to any preceding claim, characterized in that, in a time interval in which one or more traffic channels are released, the power control factor for each channel remaining active is determined according to relation

$$\alpha_i = \alpha'_i + \frac{\Delta_{j1} + ... + \Delta_{jX}}{N - X},$$

where X is the number of channels released and $\Delta_{jh} = \alpha'_{jh} - 1$, α'_{jh} (h = 1 ... X) being the power control factor assigned in the preceding interval to the generic released channel.

6. Device for power control in the base-to-mobile link within each cell of a mobile radio system with code division multiple access, in which each active mobile station (M_1 ... M_N) locked to the base station (SB) of the cell sends to the base station (SB) information, periodically updated, on the respective carrier/interference ratio, characterized in that it includes means (B_1 ...B_Q) for receiving such information and means ($U1_1$...$U1_Q$, R_1...R_Q, MT_1...MT_Q, U2, LC) for sharing among the various traffic channels towards the mobile stations the total power P available for transmission from the base station to the active mobile stations, so as to keep constant such total power, for a constant number of active channels, and to equalize the carrier/interference ratios of all the mobile stations, and in that the power sharing means ($U1_1$...$U1_Q$, R_1...R_Q, MT_1...MT_Q, U2, LC) are arranged to assign to each channel, in a time interval in which the carrier/interference ratios remain valid, a fraction Pi=α_i P/N of said total power P, where N is the number of active channels and α_i is a coefficient typical of the channel, called in the following power control factor, depends on the carrier/interference ratios of all the mobile stations, on the number of active channels, on whether or not there have been variations in the active channels with respect to the preceding interval and on the power sharing carried out in the preceding interval.

7. Device according to claim 6, characterized in that said power sharing means prise:

- a first group of arithmetic units ($U1_1...U1_Q$), whose number is the same as the maximum number of channels which can be active at the same time, the arithmetic units associated with active channels determining the power control factor ($\alpha_1 ... \alpha_N$) for the respective channel according to one out of three operation modes, respectively corresponding to no variation in active channels, activation of new channels or release of channels with respect to the preceding interval, the various power control factors ($\alpha_1...\alpha_N$) being supplied to amplifying means ($A_1...A_N$) in the transmission section of the base station (SB);

- a first group of registers ($R_1...R_Q$) connected each to one of the aforesaid arithmetic units ($U1_1...U1_Q$), the registers associated with the active channels storing the power control factors ($\alpha_1 ... \alpha_N$) calculated by the respective first arithmetic unit ($U1_1...U1_Q$) for the whole validity interval of the carrier/interference ratios;

- means ($MT_1... MT_Q$; U2) that, in the first and in the third operation mode, calculate and supply the first arithmetic units ($U1_1...U1_Q$) associated with the active channels with a first and respectively a second parameter (H, K) to be used in updating the power control factors;

- a control logic network (LC), receiving from control devices of the base station information on the active channels and generating a signal (SE) for selection of the operation mode, which signal is passed to the first arithmetic units ($U1_1, ... U1_Q$) and to the means ($MT_1 ... MT_Q$; U2) calculating said first and second parameters, the logic network also providing the latter means with at least the number of active channels in the interval.

8. Device according to claim 7, characterized in that the first arithmetic units ($U1_1 ... U1_Q$):

- in the first operation mode, determine the power control factor according to the relation $\alpha_i = H (1 + \Gamma_i) \alpha'_i$, where α'_i is the value of the power control factor for the i-th channel in the preceding interval, Γ_i is the inverse of the carrier/interference ratio of the mobile stations and H is said first parameter, given by the relation

$$H = N/(N + \sum_{i=1}^{N} \Gamma_i \cdot \alpha'_i);$$

- in the second operation mode, determine the power control factor by assigning to channels already active in the preceding interval the value (α'_i) of said power factor in said preceding interval, and by assigning to newly active channels a unit value;

- in the third operation mode, determine the power control factor for the still active channels according to the relation $\alpha_i = \alpha'_i + K$, where K is said second parameter, given by the relation

$$K = \frac{\Delta_{j1} + ... + \Delta_{jX}}{N - X},$$

where X is the number of released channels and Δ_{jh} (h = 1 ... X) indicates the quantity $\alpha'_{jh} - 1$ for the generic channel released.

9. Device according to claim 7 or 8, characterized by the fact it further includes a second group of registers ($B_1 ... B_Q$) each of which temporarily stores the value ($\Gamma_1 ... \Gamma_Q$) of the inverse of carrier/interference ratio supplied by the corresponding active mobile station ($M_1 ... M_N$) and is read at the same time as the other registers in the second group, when all the values are present, on command of a timing signal (CK) that also commands simultaneous reading of the registers ($R_1 ... R_Q$) of the first group.

10. A method of operating a mobile radio system with code division multiple access comprising a plurality of base and mobile stations (SB, $M_1 ... M_N$), wherein a power control in the base-to-mobile link is performed at each base station (SB), characterised in that said power control is performed with a method according to any of claims 1 to 5.

11. Mobile radio system with code division multiple access, which comprises a plurality of base and mobile stations, each base station (SB) including a device (CP) for power control on the base-to-mobile link according to any of the claims 6 to 9.

Patentansprüche

1. Verfahren zur Leistungssteuerung bei der Verbindung von einer Basis zu mobilen Stationen eines Mobilfunksystems mit Vielfachzugriff durch Codetrennung, bei dem jede der aktiven mobilen Stationen (M_1 ... M_N), die bei einer Basisstation (SB) eingebucht sind, ihr eigenes Verhältnis Träger/Störsignal C/I mißt und an die Basisstation (SB) periodisch fortgeschriebene Informationen über dieses Verhältnis sendet, dadurch gekennzeichnet, daß man die gesamte Leistung P unter allen für das Senden zu den mobilen Stationen aktiven Verkehrskanälen aufteilt, indem man jeder dieser Stationen in einer Zeitspanne, in der die Werte des Verhältnisses C/I gültig bleiben, einen Bruchteil Pi = $\alpha_i \cdot$ P/N dieser gesamten Leistung zuteilt, wobei N = Zahl der aktiven Kanäle, und α_i = ein für den Kanal typischer Koeffizient, der im folgenden "Leistungssteuerfaktor" bezeichnet ist, und zwar einen Bruchteil, der abhängt vom Verhältnis C/I aller mobilen Stationen, von der Zahl der aktiven Kanäle in der Zeitspanne, ferner davon, ob es Änderungen in den aktiven Kanälen im Vergleich zur vorhergehenden Zeitspanne gegeben hat oder nicht, und von der dem Kanal in der vorhergehenden Zeitspanne zugeteilten Leistung, wobei man die Leistung so auf die verschiedenen Verkehrskanäle aufteilt, daß man für eine gegebene Zahl von aktiven mobilen Stationen die gesamte von der Basisstation (SB) zu den mobilen Stationen (M_1 ... M_N) gesendete Leistung konstant hält und das Verhältnis Träger/Störsignal C/I aller mobilen Stationen (M_1 ... M_N) vergleichmäßigt.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Information über das Verhältnis Träger/Störsignal, die von den mobilen Stationen (M_1 ... M_N) gesendet wird, der Kehrwert (Γ_1 ... Γ_N) dieses Verhältnisses ist.

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß man in jeder Zeitspanne, in der es keine Veränderungen in den aktiven Kanälen gibt, den Leistungssteuerfaktor α_i (i = 1 ... N) für einen aktiven Kanal gemäß der Beziehung $\alpha_i = H (1 + \Gamma_i) \alpha'_i$ berechnet, wobei α'_i der Wert des Leistungssteuerfaktors für diesen Kanal in der vorhergehenden Zeitspanne ist, Γ_i die oben angegebene Bedeutung hat und H ein durch die Beziehung

$$H \;=\; N/(N + \sum_{i=1}^{N} \Gamma_i \cdot \alpha'_i)$$

gegebener Parameter ist.

4. Verfahren nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß in einer Zeitspanne, in der neue Verkehrskanäle aktiviert werden, man jedem bereits aktiven Kanal den gleichen Wert α'_i des Leistungssteuerfaktors, der ihm in der vorhergehenden Zeitspanne gegeben worden war, zuteilt und neuen Kanälen einen Einheits-Leistungssteuerfaktor zuteilt.

5. Verfahren nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß man in einer Zeitspanne, in der einer oder mehrere Verkehrskanäle wegfallen, den Leistungssteuerfaktor für jeden aktiv bleibenden Kanal gemäß der Beziehung

$$\alpha'_i = \alpha'_i + \frac{\Delta_{j1} + ... + \Delta_{jX}}{N - X}$$

bestimmt, wobei X = Anzahl der weggefallenen Kanäle, und $\Delta_{jh} = \alpha'_{jh} - 1$, wobei α'_{jh} (h = 1 ... X) = der in der vorhergehenden Zeitspanne dem allgemeinen weggefallenen Kanal zugeteilte Leistungssteuerfaktor.

6. Vorrichtung zur Leistungssteuerung bei der Verbindung von einer Basis zu mobilen Teilnehmern innerhalb jeder Zelle eines Mobilfunksystems mit Vielfachzugriff durch Codetrennung, bei der jede in der Basisstation (SB) der Zelle gebuchte aktive mobile Station (M_1 ... M_N) an die Basisstation (SB) periodisch fortgeschriebene Informationen über das jeweilige Verhältnis Träger/Störsignal sendet, dadurch gekennzeichnet, daß sie Einrichtungen (B_1 ... B_Q) für den Empfang dieser Informationen und Einrichtungen ($U1_1$ ... $U1_Q$, R_1 ... R_Q, MT_1 ... MT_Q, U2, LC) zum Aufteilen der für das Senden von der Basisstation zu den aktiven mobilen Stationen verfügbaren gesamten Leistung P unter den verschiedenen Verkehrskanälen zu den mobilen Stationen enthält, um so diese gesamte Leistung für eine konstante Anzahl aktiver Kanäle konstant zu halten und das Verhältnis Träger/Störsignal aller mobilen Stationen zu vergleichmäßigen; und daß die Leistungsaufteileinrichtungen ($U1_1$ ... $U1_Q$, R_1 ... R_Q, MT_1 ... MT_Q, U2, LC) dazu eingerichtet sind, jedem Kanal in einer Zeitspanne, in der die Verhältnisse Träger/Störsignal gültig bleiben, einen

Bruchteil Pi = $\alpha_i \cdot$ P/N der gesamten Leistung P zuzuteilen, wobei N = Zahl der aktiven Kanäle und α_i = ein für den Kanal typischer Koeffizient, der im folgenden als Leistungssteuerfaktor bezeichnet ist, und zwar einen Bruchteil, der abhängt vom Verhältnis Träger/Störsignal aller mobilen Stationen, von der Zahl der aktiven Kanäle, davon, ob es Veränderungen in den aktiven Kanälen in Bezug zur vorhergehenden Zeitspanne gegeben hat, und von der in der vorhergehenden Zeitspanne durchgeführten Leistungsaufteilung.

7. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß die Einrichtungen zur Leistungsaufteilung folgende Schaltungen umfassen:

- eine erste Gruppe von Recheneinheiten ($U1_1$ ... $U1_Q$), deren Anzahl gleich der Maximalzahl von Kanälen ist, die gleichzeitig aktiv sein können, wobei die aktiven Kanälen zugeordneten Recheneinheiten den Leistungssteuerfaktor (α_1 ... α_N) für den jeweiligen Kanal gemäß einem von drei Betriebsmoden bestimmen, die den Gegebenheiten: keine Änderung in den aktiven Kanälen, Aktivierung neuer Kanäle, oder Wegfall von Kanälen in Bezug zur vorhergehenden Zeitspanne, entsprechen; wobei die verschiedenen Leistungssteuerfaktoren (α_1 ... α_N) Verstärkungseinrichtungen (A_1 ... A_N) im Sendeabschnitt der Basisstation (SB) eingespeist werden;
- eine erste Gruppe von Registern (R_1 ... R_Q), die jeweils mit einer der genannten Recheneinheiten ($U1_1$ ... $U1_Q$) verbunden sind, wobei die den aktiven Kanälen zugeordneten Register die Leistungssteuerfaktoren (α_1 ... α_N) speichern, die von der betreffenden ersten Recheneinheit ($U1_1$ ... $U1_Q$) für die gesamte Gültigkeits-Zeitspanne der Verhältnisse Träger/Störsignal berechnet sind;
- eine Einrichtung (MT_1 ... MT_Q; U2), die beim ersten und beim dritten Betriebsmodus einen ersten bzw. einen zweiten Parameter (H, K), der beim Fortschreiben der Leistungssteuerfaktoren verwendet wird, berechnet und damit die ersten Recheneinheiten ($U1_1$ ... $U1_Q$), denen aktive Kanäle zugeordnet sind, beliefert.
- eine logische Steuerschaltung (LC), die von Steuervorrichtungen der Basisstation Informationen über die aktiven Kanäle empfängt und ein Signal (SE) zum Wählen des Betriebsmodus erzeugt, das zu den ersten Recheneinheiten ($U1_1$ ... $U1_Q$) und zur die ersten und zweiten Parameter berechnenden Einrichtung (MT_1 ... MT_Q; U2) weitergegeben wird, wobei die logische Schaltung auch diese letztere Einrichtung mit wenigstens der Zahl der in der Zeitspanne aktiven Kanäle versorgt.

8. Vorrichtung nach Anspruch 7, dadurch gekennzeichnet, daß die ersten Recheneinheiten ($U1_1$ ... $U1_Q$):

- beim ersten Betriebsmodus den Leistungssteuerfaktor gemäß der Beziehung $\alpha_i = H (1 + \Gamma_i)\, \alpha'_i$ bestimmen, wobei α'_i = der Wert des Leistungssteuerfaktors für den i-ten Kanal in der vorhergehenden Zeitspanne, Γ_i = der Kehrwert des Verhältnisses Träger/Störsignal der mobilen Stationen, und H = der erste Parameter, der durch die Beziehung gegeben ist:

$$H \;=\; N/(N + \sum_{i=1}^{N} \Gamma_i \cdot \alpha'_i)$$

- beim zweiten Betriebsmodus den Leistungssteuerfaktor dadurch bestimmen, daß sie den bereits in der vorhergehenden Zeitspanne aktiven Kanälen den Wert (α'_i) des Leistungsfaktors in der vorhergehenden Zeitspanne zuteilen und den neu-aktiven Kanälen einen Einheitswert zuteilen;
- beim dritten Operationsmodus den Leistungssteuerfaktor für die noch aktiven Kanäle gemäß der Beziehung $\alpha_i = \alpha'_i + K$ bestimmen, wobei K der zweite Parameter ist, der durch die Beziehung

$$K = \frac{\Delta_{j1} + ... + \Delta_{jX}}{N - X}$$

gegeben ist, wobei wiederum X = Zahl der weggefallenen Kanäle, und Δ_{jh} (h = 1 ... X) die Menge α'_{jh} - 1 für den allgemeinen weggefallen Kanal angibt.

9. Vorrichtung nach Anspruch 7 oder 8, dadurch gekennzeichnet, daß sie weiterhin eine zweite Gruppe von Registern (B_1 ... B_Q) umfaßt, von denen jedes vorübergehend den Wert (Γ_1 ... Γ_Q) des Kehrwerts des Verhältnisses Träger/Störsignal speichert, der von der entsprechenden aktiven mobilen Station (M_1 ... M_N) geliefert wird, und gleichzeitig mit den anderen Register in der zweiten Gruppe gelesen wird, wenn alle Werte vorliegen, und zwar auf Befehl durch ein Zeitsteuersignal (CK), das auch das gleichzeitige Lesen der Register (R_1 ... R_Q) der ersten Gruppe

steuert.

10. Verfahren zum Betrieb eines Mobilfunksystems mit Vielfachzugriff durch Codetrennung und mit einer Mehrzahl von Basisstationen (SB) und mobilen Stationen (M_1 ... M_N), bei dem in jeder Basisstation (SB) eine Leistungssteuerung in der Verbindung von der Basis zu den mobilen Teilnehmern bewirkt wird, dadurch gekennzeichnet, daß die Leistungssteuerung durch ein Verfahren gemäß einem der Ansprüche 1 bis 5 bewirkt wird.

11. Mobilfunksystem mit Vielfachzugriff durch Codetrennung und mit einer Mehrzahl von Basisstationen und mobilen Stationen, bei dem jede Basisstation (SB) eine Vorrichtung (CP) zur Leistungssteuerung für die Verbindung der Basis zu den mobilen Teilnehmern gemäß einem der Ansprüche 6 bis 9 enthält.

Revendications

1. Procédé de contrôle de puissance en lien de la station de base à la station mobile d'un système de radiotéléphonie mobile avec accès multiple par répartition de code, dans lequel chacune des stations mobiles actives (M_1 ... M_N) reliées à une station de base (SB) mesure son propre rapport signal/interférence C/I et fournit à la station de base (SB) des informations sur ce rapport, mises à jour périodiquement, caractérisé en ce que la puissance globale P est répartie parmi tous les canaux de trafic actifs pour la transmission vers les stations mobiles en assignant à chacun d'eux, pour tout un intervalle de temps dans lequel les valeurs du rapport C/I restent valables, une fraction $P_i = \alpha_i \cdot P/N$ de cette puissance globale, où N est le nombre de canaux actifs et α_i est un coefficient typique du canal, nommé par la suite facteur de contrôle de puissance, fraction qui dépend du rapport C/I de toutes les stations mobiles, du nombre de canaux actifs dans l'intervalle, du fait qu'il y ait eu ou non des variations dans les canaux actifs par rapport à l'intervalle précédent et de la puissance assignée au canal dans l'intervalle précédent, la répartition de puissance entre les différents canaux de trafic étant telle qu'on maintient constante, pour un nombre donné de stations mobiles actives, la puissance globale transmise de la station de base (SB) vers les stations mobiles (M_1 ... M_N) et on égalise les rapports signal/interférence C/I de toutes les stations mobiles (M_1 ... M_N).

2. Procédé selon la revendication 1, caractérisé en ce que les informations sur le rapport signal/interférence fournies par les stations mobiles (M_1 ... M_N) sont représentées par l'inverse (Γ_1 ... Γ_N) de ce rapport.

3. Procédé selon la revendication 1 ou 2, caractérisé en ce que dans chaque intervalle dans lequel in n'y a pas de variations des canaux actifs, on détermine le facteur de contrôle de puissance α_i (i = 1 ... N) pour un canal actif selon la relation $\alpha_i = H (1 + \Gamma_i) \alpha'_i$, où α'_i est la valeur du facteur de contrôle de puissance pour ce canal dans l'intervalle précédent, Γ_i a la signification susdite et H est un paramètre donné par

$$H = N/(N + \sum_{i=1}^{N} \Gamma_i \cdot \alpha'_i).$$

4. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que, dans un intervalle de temps dans lequel de nouveaux canaux de trafic sont activés, à chaque canal déjà actif on assigne la même valeur α'_i du facteur de contrôle de puissance qui lui avait été assignée dans l'intervalle précédent, et on assigne aux nouveaux canaux un facteur de contrôle de puissance unitaire.

5. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que, dans un intervalle de temps dans lequel un ou plusieurs canaux de trafic sont libérés, on détermine le facteur de contrôle de puissance pour chaque canal qui reste actif selon la relation

$$\alpha_i = \alpha'_i + \frac{\Delta_{j1} + ... + \Delta_{jX}}{N - X},$$

où X est le nombre de canaux qui ont été libérés, et $\Delta_{jh} = \alpha'_{jh} - 1$, α'_{jh} (h = 1 ... X) étant le facteur de contrôle assigné dans l'intervalle précédent à un canal libéré quelconque.

6. Dispositif de contrôle de puissance en lien de la station de base à la station mobile à l'intérieur de chaque cellule

d'un système de radiotéléphonie mobile avec accès multiple par répartition de code, dans lequel chaque station mobile active (M_1 ... M_N) reliée à la station de base (SB) de la cellule envoient à la station de base (SB) des informations, mises à jour périodiquement, sur le rapport signal/interférence respectif, caractérisé en ce qu'il comprend des moyens (B_1 ... B_Q) pour recevoir ces informations et des moyens ($U1_1$ ... $U1_Q$, R_1 ... R_Q, MT_1 ... MT_Q, U2, LC) pour répartir parmi les différents canaux de trafic vers les stations mobiles la puissance globale P disponible pour la transmission de la station de base vers les stations mobiles actives, de manière à maintenir constante cette puissance globale, pour un nombre de canaux actifs constant, et à égaliser les rapports signal/interférence de toutes les stations mobiles, et en ce que les moyens de répartition de la puissance ($U1_1$ ... $U1_Q$, R_1 ... R_Q, MT_1 ... MT_Q, U2, LC) sont en mesure d'assigner à chaque canal, dans un intervalle de temps dans lequel les valeurs du rapport signal/interférence restent valables, une fraction $Pi = \alpha_i \cdot P/N$ de ladite puissance globale P, où N est le nombre de canaux actifs et α_i est un coefficient typique de canal, nommé par la suite facteur de contrôle de puissance, fraction qui dépend du rapport signal/interférence de toutes les stations mobiles, du nombre de canaux actifs, du fait qu'il y ait eu ou non des variations dans les canaux actifs par rapport à l'intervalle précédent, et de la répartition de puissance effectuée dans l'intervalle précédent.

7. Dispositif selon la revendication 6, caractérisé en ce que lesdits moyens de répartition de la puissance comprennent:

    -   un premier groupe d'unités arithmétiques ($U1_1$ ... $U1_Q$), dont le nombre est égal au nombre maximum de canaux qui peuvent être actifs simultanément, les unités arithmétiques associées aux canaux actifs déterminant le facteur de contrôle de puissance (α_1 ... α_N) pour le canal respectif selon l'un de trois modes opérationnels correspondant respectivement à: aucune variation dans les canaux actifs, activation de nouveaux canaux ou libération de canaux par rapport à l'intervalle précédent, les différents facteurs de contrôle de puissance (α_1 ... α_N) étant fournis a des moyens d'amplification (A_1 ... A_N) dans la section de transmission de la station de base (SB);
    -   un premier groupe de registres (R_1 ... R_Q), dont chacun est connecté à l'une desdites unités arithmétiques ($U1_1$ ... $U1_Q$), les registres associés aux canaux actifs mémorisant les facteurs de contrôle de puissance (α_1 ... α_N) calculés par la première unité arithmétique respective ($U1_1$ ... $U1_Q$) pour toute la durée de l'intervalle de validité des rapports signal/interférence;
    -   des moyens (MT_1 ... MT_Q; U2) qui, dans le premier et dans le troisième mode opérationnel, calculent et fournissent aux premières unités arithmétiques ($U1_1$ ... $U1_Q$) associées aux canaux actifs un premier et respectivement un deuxième paramètre (H, K) à utiliser pour la mise à jour des facteurs de contrôle de puissance;
    -   un réseau logique de commande (LC) qui reçoit de dispositifs de gestion de la station de base des informations sur les canaux actifs et engendre un signal (SE) de sélection du mode opérationnel, signal qui est fourni aux premières unités arithmétiques ($U1_1$ ... $U1_Q$) et aux moyens (MT_1 ... MT_Q; U2) de calcul du premier et du deuxième paramètre, le réseau logique fournissant également à ces derniers au moins le nombre de canaux actifs dans l'intervalle.

8. Dispositif selon la revendication 7, caractérisé en ce que les premières unités arithmétiques ($U1_1$ ... $U1_Q$):

    -   dans le premier mode opérationnel, déterminent le facteur de contrôle de puissance selon la relation $\alpha_i = H (1 + \Gamma_i) \alpha'_i$, où α'_i est la valeur du facteur de contrôle de puissance pour l'i-ème canal dans l'intervalle précédent, Γ_i est l'inverse du rapport signal/interférence des stations mobiles et H est ledit premier paramètre, donné par la relation

$$H = N/(N + \sum_{i=1}^{N} \Gamma_i \cdot \alpha'_i) ;$$

    -   dans le deuxième mode opérationnel, déterminent le facteur de contrôle de puissance en assignant aux canaux déjà actifs dans l'intervalle précédent la valeur (α'_i) dudit facteur de contrôle de puissance dans ledit intervalle précédent, et en assignant aux nouveaux canaux actifs une valeur unitaire;
    -   dans le troisième mode opérationnel, déterminent le facteur de contrôle de puissance pour les canaux encore actifs, selon la relation $\alpha_i = \alpha'_i + K$, où K est ledit deuxième paramètre, donné par la relation

$$K = \frac{\Delta_{j1} + ... + \Delta_{jX}}{N - X},$$

où X est le nombre de canaux libérés et Δ_{jH} (h = 1 ... X) est la quantité α'_{jh} - 1 pour un canal libéré quelconque.

9. Dispositif selon la revendication 7 ou 8, caractérisé en ce qu'il comprend en outre un deuxième groupe de registres $(B_1 ... B_Q)$ dont chacun mémorise temporairement la valeur $(\Gamma_1 ... \Gamma_Q)$ de l'inverse du rapport signal/interférence fournie par la station mobile active $(M_1 ... M_N)$ correspondante et est lu au même temps que les autres registres du deuxième groupe, quand toutes les valeurs sont présentes, d'après la commande d'un signal de temps (CK) qui commande également la lecture simultanée des registres $(R_1 ... R_Q)$ du premier groupe.

10. Procédé d'exploitation d'un système de radiotéléphonie mobile avec accès multiple par répartition de code, qui comprend une pluralité de stations de base (SB) et de stations mobiles $(M_1 ... M_N)$, dans lequel dans chaque station de base (SB) on effectue un contrôle de puissance en lien de la station de base à la station mobile, caractérisé en ce que ledit contrôle de puissance est effectué avec le procédé selon l'une quelconque des revendications de 1 à 5.

11. Système de radiotéléphonie mobile avec accès multiple par répartition de code, qui comprend une pluralité de stations de base et de stations mobiles, chaque station (SB) comprenant un dispositif (CP) pour le contrôle de puissance en lien de la station de base à la station mobile selon l'une quelconque des revendications de 6 à 9.
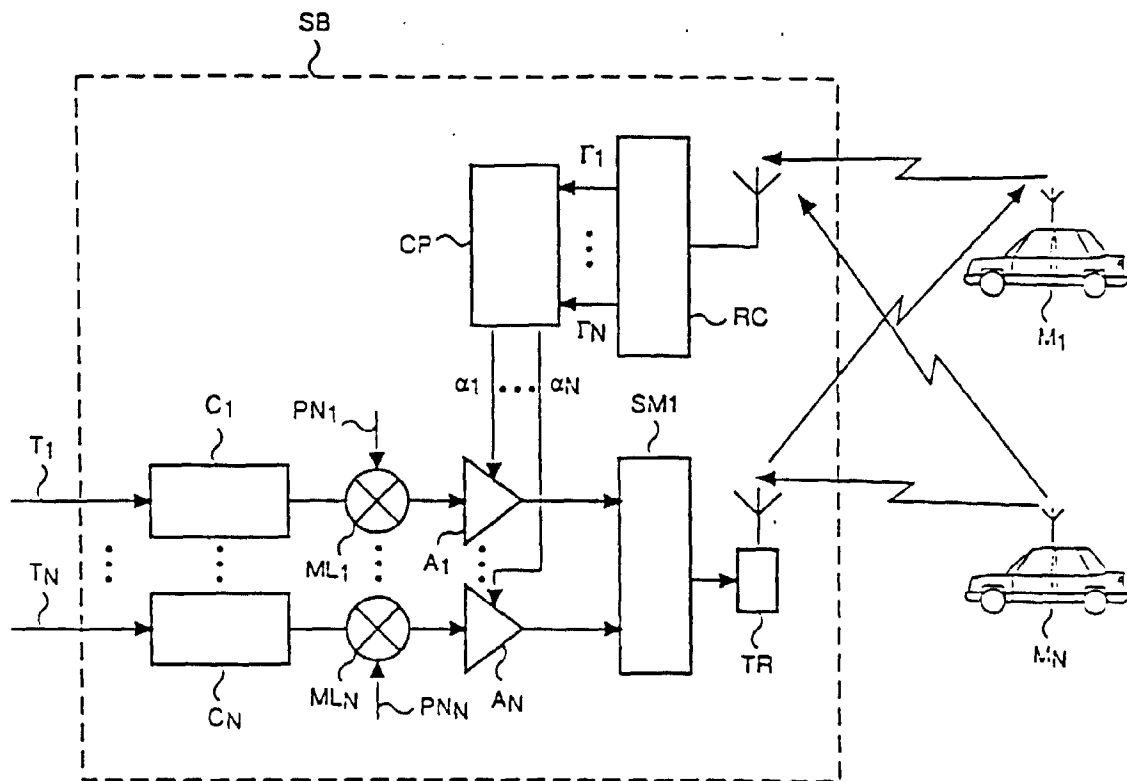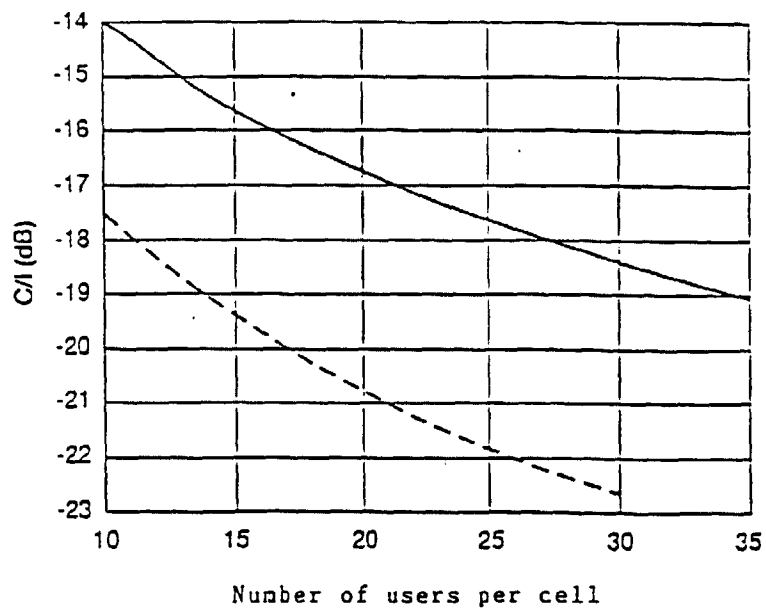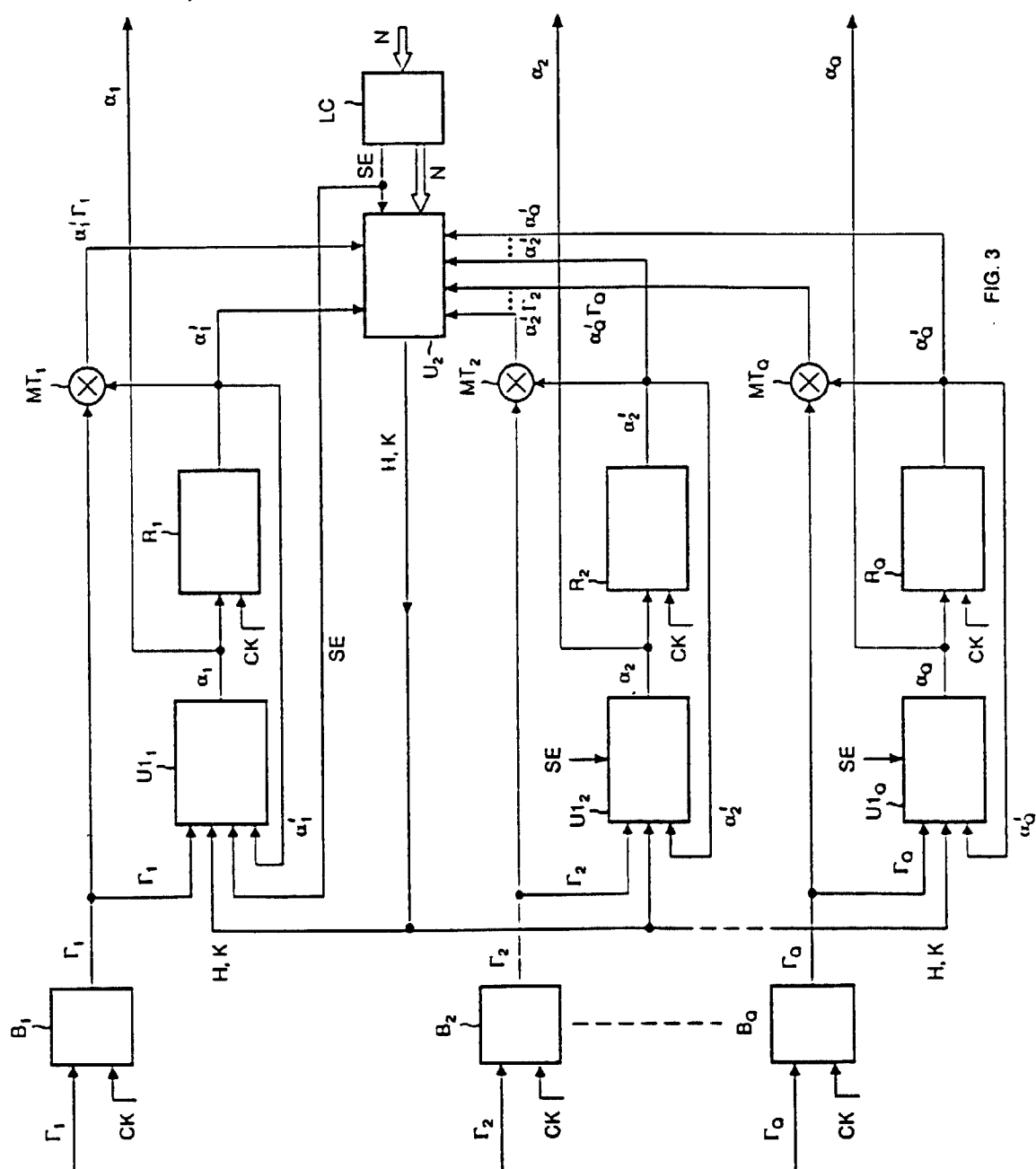
FIG. 1

Number of users per cell

FiG. 2

FIG. 3